(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number : **0 663 248 A1**

(12) EUROPEAN PATENT APPLICATION

(21) Application number : **95300114.6**

(51) Int. Cl.[6] : **B21D 53/84**, B21C 37/16

(22) Date of filing : **10.01.95**

(30) Priority : **12.01.94 US 180247**

(43) Date of publication of application :
19.07.95 Bulletin 95/29

(84) Designated Contracting States :
DE FR GB

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(54) Method of making a camshaft.

(57) A method of forming a camshaft tube having a plurality of thinner wall sections adjacent to thicker wall sections. The diameter of a hollow tube (13) is mechanically reduced with a retractable mandrel (50) inserted in the hollow tube. The retractable mandrel has a first portion (54) having a larger diameter than an adjacent second portion (52). To form a thinner wall section, the larger diameter first portion is positioned under a reducing tool (60). To form a thicker portion, the smaller diameter second portion is positioned under a reducing tool.

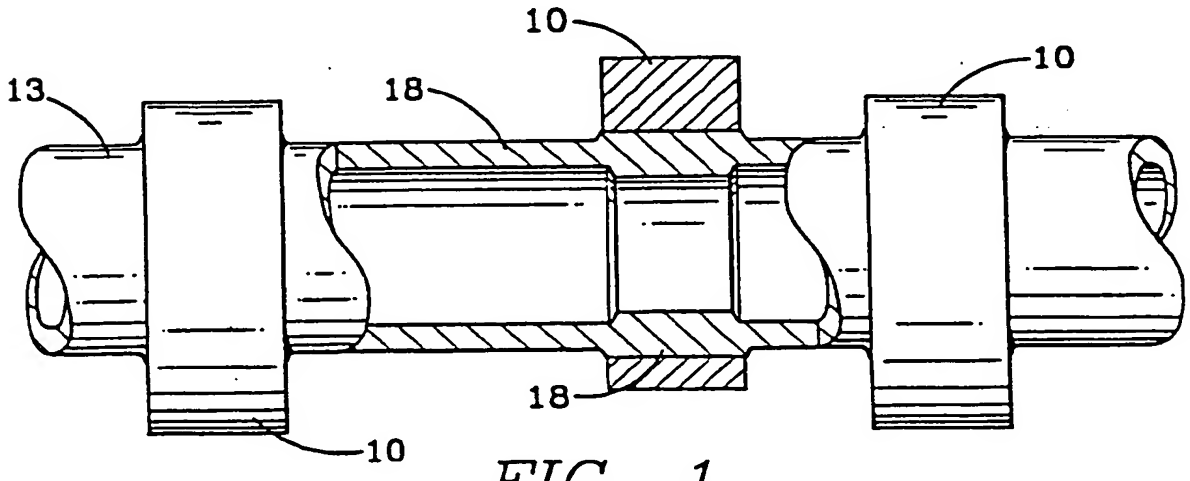

FIG. 1

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This invention relates generally to camshafts for reciprocating piston engines and more particularly to a method of making a camshaft where the cams and shaft are produced as individual elements and are fastened together forming the camshaft.

One method of manufacturing camshafts involves forming the cams separately by methods such as powdered metallurgy. The cams are then fastened to a hollow tube using known fastening processes, such as welding, brazing or expansion of the hollow tube. Bearing or journal surfaces are machined onto the hollow tube between cams. Another method of attaching the cams, described in US-A-4 858 295, leaves a plurality of projections on the outside of the hollow tube between cams. These projections must be removed in order to form the journal surfaces.

The displacement of material caused by an expander tool during expansion of the hollow tube induces work hardening and stress into the tube. Limiting work hardening reduces the risk of failure due to tube splitting.

According to one aspect of the present invention, there is provided a method of forming a camshaft tube comprising the steps of providing a hollow tube, providing a retractable mandrel, the retractable mandrel having a first portion and a second portion adjacent the first portion, the diameter of the first portion being larger than the diameter of the second portion, inserting the retractable mandrel into the hollow tube, mechanically reducing a first section of the hollow tube, the first portion of the retractable mandrel being positioned under the section of the hollow tube being reduced, positioning the second portion of the retractable mandrel under a second section of the hollow tube, and mechanically reducing the second section of the hollow tube, the second portion of the retractable mandrel being positioned under the section of the hollow tube being reduced.

According to a second aspect of the present invention, there is provided a method of forming a camshaft tube comprising the steps of providing a hollow tube, providing an axially extending retractable mandrel, the retractable mandrel having a first portion and a second portion adjacent the first portion, the diameter of the first portion being larger than the diameter of the second portion, the second portion being an end of the retractable mandrel, inserting the retractable mandrel into the hollow tube, positioning the retractable mandrel whereby the first portion of the retractable mandrel is positioned under a first section of the hollow tube and providing a swaging tool; mechanically reducing the first section of the hollow tube by pushing the hollow tube through the swaging tool, the retractable mandrel also being moved to keep the first portion of the retractable mandrel positioned under the section of the hollow tube being reduced, retracting the retractable mandrel to position the second portion of the retractable mandrel under a second section of the hollow tube, mechanically reducing the second section of the hollow tube, repeating the steps of positioning the retractable mandrel whereby the first portion of the retractable mandrel is positioned under a first section of the hollow tube, mechanically reducing the first section of the hollow tube by pushing the hollow tube through the swaging tool, the retractable mandrel also being moved to keep the first portion of the retractable mandrel positioned under the section of the hollow tube being reduced, retracting the retractable mandrel to position the second portion of the retractable mandrel under a second section of the hollow tube, and mechanically reducing the second section of the hollow tube by pushing the hollow tube through the swaging tool, thereby forming a plurality of first sections and second sections, the inner diameter of a first section being larger than the inner diameter of a second section.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 is a cross-section in part of a camshaft;

Figure 2 is a cross-section of a hollow tube shown in Figure 1 after it has been mechanically reduced, showing cams located about the tube;

Figure 3 is a cross-section view taken along line 3-3 of Figure 2;

Figure 4 is a cross-section of the camshaft showing the cams after an expander tool has moved partially through the hollow tube; and

Figures 5A to 5D are cross-sections of a hollow tube illustrating the steps of forming the hollow tube shown in Figure 2 using a retractable mandrel.

Referring to the drawings and more particularly to Figure 1, the manufacture of the camshaft is accomplished by slipping cams 10 over a hollow tube 13. Other elements in addition to cams 10 may be attached to the hollow tube 13 using this method. This includes timing gears, thrust washers, bearing rings, etc. The hollow tube 13 has a plurality of areas 16 which have a thicker wall thickness than the adjacent areas 18. The cams 10 are positioned about the thicker wall areas 16. Some of the thinner wall areas 18 are used as bearing or journal surfaces.

The hollow tube 13 is preferably made of formable steel having a maximum hardness of R_c30. The cams 10 are preferably made of steel which is hardenable to a minimum hardness of R_c55. Powder forged AISI 4680 series material has also been successfully used as cams 10.

The preferred method for forming the hollow tube 13 with a plurality of thinner areas (or first sections) 18 and thicker areas (or second sections) 16 utilises a swaging operation as illustrated in Figures 5A through 5D. A retractable mandrel 50 is inserted into a hollow tube 13. The retractable mandrel 50 has a

first portion 54 and an adjacent second portion 52. The diameter of the first portion 54 is larger than the diameter of the second portion 52. As shown in the drawings, the second portion 52 is an end portion on a free end of the retractable mandrel 50. The other end of the retractable mandrel 50 is attached to a machine (not shown).

The retractable mandrel 50 is positioned within the hollow tube 13 with the larger diameter first portion 54 under a swaging tool or die 60, as shown in Figure 5A. The hollow tube 13 and retractable mandrel 50 are then pushed through the swaging tool 60, from left to right in Figures 5A to 5D, reducing the outer diameter of the hollow tube 13 and forming a thinner area or first section 18 of the hollow tube 13. The retractable mandrel 50 is then retracted to the left to position the smaller diameter second portion 52 under swaging tool 60. The hollow tube is continued to be pushed through the swaging tool 60, reducing the outer diameter of the hollow tube 13 and forming a thicker area or second section 16 of the hollow tube 13, as shown in Figure 5B. After the second section 16 is formed, the retractable mandrel 50 and the hollow tube 13 are both pushed through the swaging tool 60, as shown in Figure 5C, forming another thinner area or first section 18. The retractable mandrel 50 is then retracted to the left to position the smaller diameter second portion 52 under the swaging tool 60 and the hollow tube 13 is continued to be pushed through the swaging tool 60, forming an additional thicker area or second section 16 of the hollow tube 13, as shown in Figure 5D.

The steps of forming additional first sections 18 and second sections 16 are repeated until a complete tube 13 with multiple thinner areas 18 and multiple thicker areas 16, as shown in Figure 2, is formed. Preferably, the swaging tool 60 reduces the outer diameter of the hollow tube 13 to the final diameter, such that no additional machining or reduction of the hollow tube 13 is required.

The diameter of the first and second portions 54, 52 of the retractable mandrel 50 determine the inner diameter of the first and second sections 18, 16 of the hollow tube 13. Since the outer diameter of the hollow tube 13 is kept constant, the first sections 18 of the hollow tube 13 are thinner than the second sections 16 of the hollow tube 13.

The preferred axial length for the thicker areas 16 is slightly less than the axial length of a cam 10. This should minimise or preclude any change in the outer diameter of the thinner areas 18 when the cams 10 are fastened to the hollow tube 13.

The cams 10 are then assembled on the hollow tube 13 as shown in Figure 2. Each cam 10 is aligned with a thicker wall area 16. The axial opening of the cam 10 is slightly larger than the outer diameter of the hollow tube, creating a slight gap between the cam 10 and the tube 13 as shown in Figures 2 and 3.

The cams 10 are held in the proper angular alignment while an expander tool 36 is inserted into the hollow tube 13. Figure 4 shows the expander tool 36 after it has been inserted past two cams 10. The outer diameter of the expander tool 36 is larger than the inner diameter of the thicker wall areas 16. The outer diameter is also smaller than the inner diameter of the thinner wall areas 18. As the expander tool 36 is inserted into the hollow tube 13, the thicker wall areas 16 are expanded outward into contact with the axial opening of the cam 10. This expansion locks the cams 10 and the hollow tube 13 into mechanical interference engagement, thereby providing axial retention of the cams 10. Since the outer diameter of the expander tool 36 is smaller than the inner diameter of the thinner wall areas 18, these areas are not expanded during the insertion of the expander tool 36. Therefore, these areas 18 typically do not require any additional post assembly machining.

Claims

1. A method of forming a camshaft tube comprising the steps of providing a hollow tube (13), providing a retractable mandrel (50), the retractable mandrel having a first portion (54) and a second portion (52) adjacent the first portion, the diameter of the first portion being larger than the diameter of the second portion, inserting the retractable mandrel into the hollow tube, mechanically reducing a first section (18) of the hollow tube, the first portion of the retractable mandrel being positioned under the section of the hollow tube being reduced, positioning the second portion of the retractable mandrel under a second section (16) of the hollow tube, and mechanically reducing the second section of the hollow tube, the second portion of the retractable mandrel being positioned under the section of the hollow tube being reduced.

2. A method according to claim 1, further comprising repeating the steps of mechanically reducing the first section (18) of the hollow tube (13), the first portion (54) of the retractable mandrel (50) being positioned under the section of the hollow tube being reduced; positioning the second portion of the retractable mandrel under the second section (52) of the hollow tube and mechanically reducing the second section (16) of the hollow tube, the second portion of the retractable mandrel being positioned under the section of the hollow tube being reduced, thereby forming a plurality of first sections (18) and second sections (16), the inner diameter of a said first section being larger than the inner diameter of a said second section.

3. A method according to claim 1 or 2, further comprising providing a swaging tool (60) and using the swaging tool mechanically to reduce the hollow tube.

4. A method of forming a camshaft tube comprising the steps of providing a hollow tube (13), providing an axially extending retractable mandrel (50), the retractable mandrel having a first portion (50) and a second portion (52) adjacent the first portion, the diameter of the first portion being larger than the diameter of the second portion, the second portion being an end of the retractable mandrel, inserting the retractable mandrel into the hollow tube, positioning the retractable mandrel whereby the first portion of the retractable mandrel is positioned under a first section (18) of the hollow tube and providing a swaging tool (60); mechanically reducing the first section of the hollow tube by pushing the hollow tube through the swaging tool, the retractable mandrel also being moved to keep the first portion of the retractable mandrel positioned under the section of the hollow tube being reduced, retracting the retractable mandrel to position the second portion of the retractable mandrel under a second section of the hollow tube, mechanically reducing the second section of the hollow tube, repeating the steps of positioning the retractable mandrel whereby the first portion of the retractable mandrel is positioned under a first section of the hollow tube, mechanically reducing the first section of the hollow tube by pushing the hollow tube through the swaging tool, the retractable mandrel also being moved to keep the first portion of the retractable mandrel positioned under the section of the hollow tube being reduced, retracting the retractable mandrel to position the second portion of the retractable mandrel under a second section of the hollow tube, and mechanically reducing the second section of the hollow tube by pushing the hollow tube through the swaging tool, thereby forming a plurality of first sections and second sections, the inner diameter of a first section being larger than the inner diameter of a second section.

5. A method according to any one of the preceding claims, and comprising providing a plurality of cam elements (10), each cam element including an axial opening, inserting the hollow tube (13) into the cam elements, each cam element being positioned about a reduced diameter zone, and expanding the reduced diameter zones of the hollow tube into mechanical interference engagement with the cam elements.

6. A method according to claim 5, wherein the areas of the hollow tube adjacent the reduced diameter zones define larger diameter zones and the larger diameter zones do not expand during the step of expanding the reduced diameter zones.

7. A method according to claim 6, further comprising providing an expander tool (36) having a diameter larger than the inner diameter of the thicker wall zones and smaller than the inner diameter of the thinner wall zones; and using the expander tool (36) to expand the thicker wall zones of the hollow tube into mechanical interference engagement with the cam elements (10) by inserting the expander tool into the hollow tube.

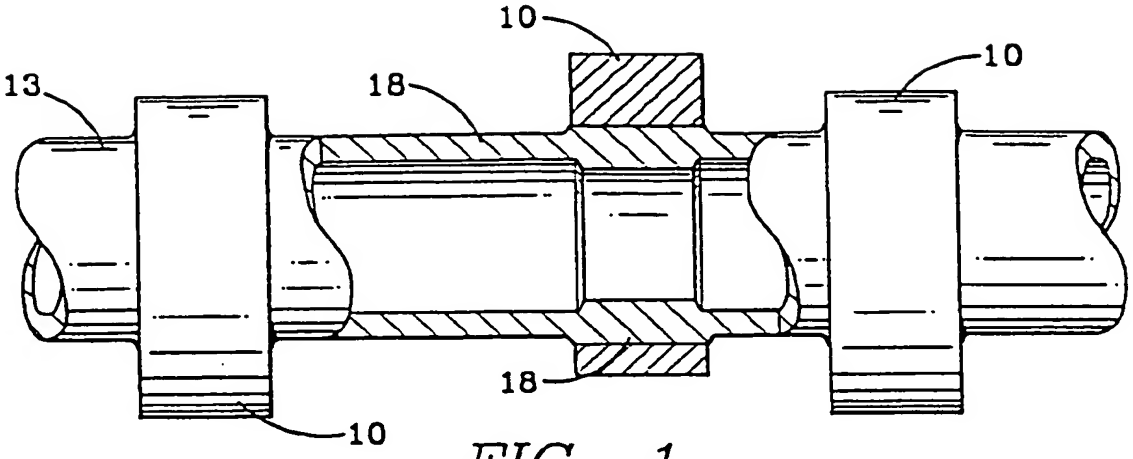

FIG. 1

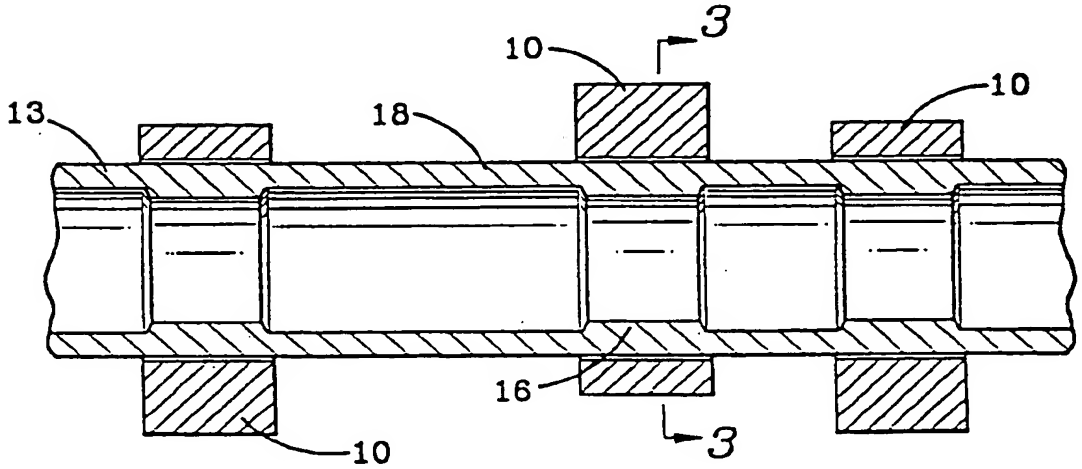

FIG. 2

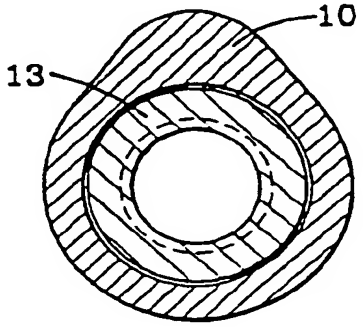

FIG. 3

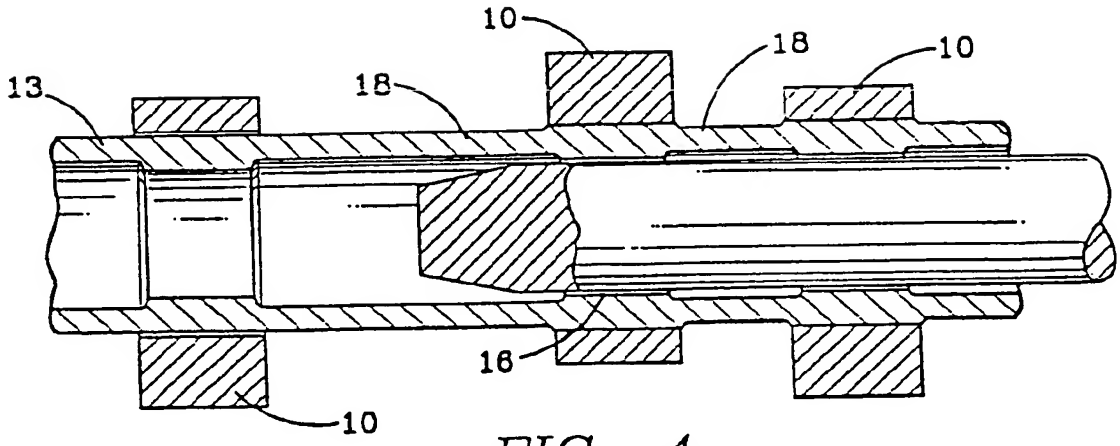

FIG. 4

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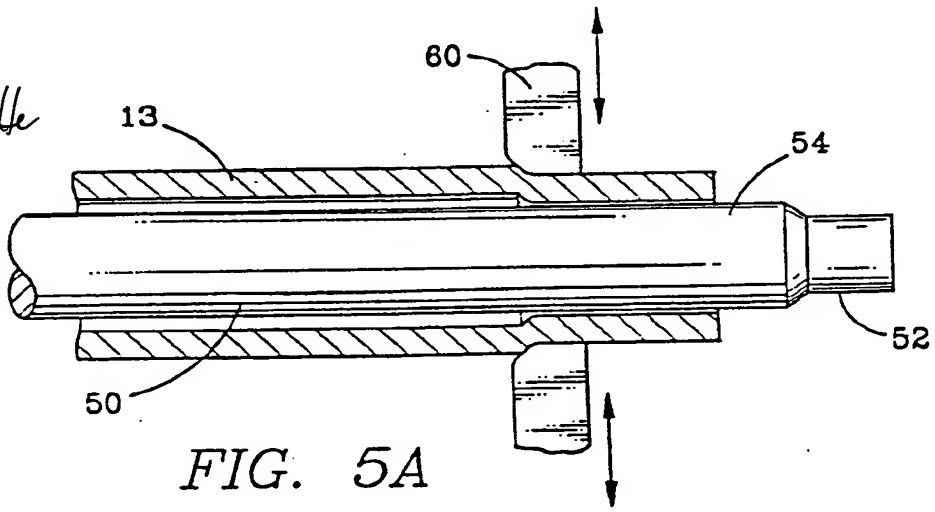

FIG. 5A

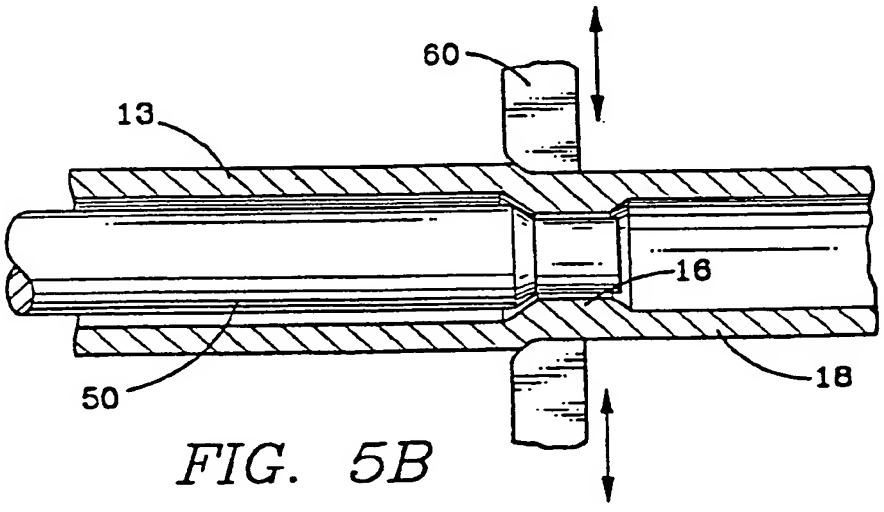

FIG. 5B

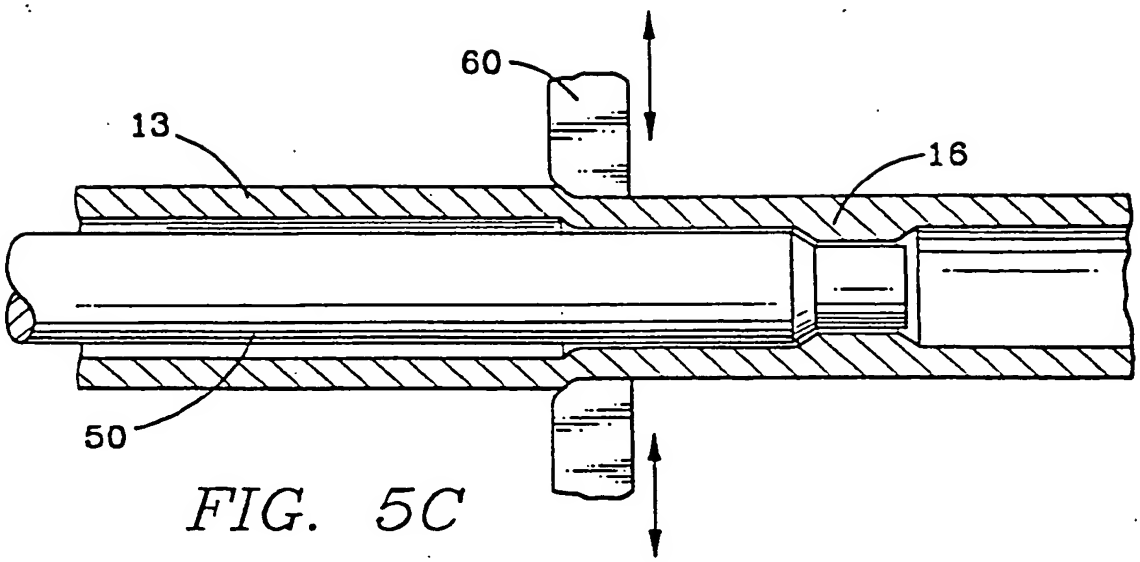

FIG. 5C

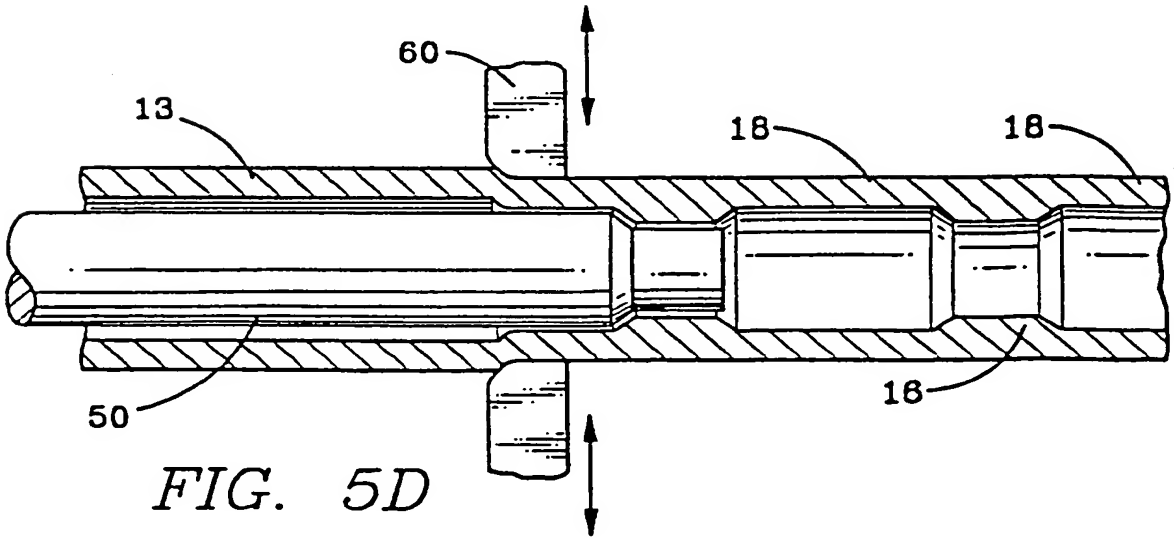

FIG. 5D

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EUROPEAN SEARCH REPORT

Application Number
EP 95 30 0114

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X Y	DE-A-31 33 804 (MANNESMANN) * the whole document *	1-4 5,6	B21D53/84 B21C37/16
Y	EP-A-0 324 499 (EMITEC GMBH) * claims 1,7; figure 1 *	5,6	
X	FR-A-732 579 (VEREINIGTE STAHLWERKE AG) * the whole document *	1,2	
X	FR-A-2 326 993 (ETS J. DEGOND SA) * page 3, line 34 - line 39; claims 1,6; figures 8,9 *	1	
A	EP-A-0 106 751 (PENCE) * claims 1,3 *	4	
A	GB-A-2 050 207 (MANNESMANN) * claim 4; figure 1 *	7	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B21D
B21C
B21J
B21K

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 April 1995	Gerard, O

CATEGORY OF CITED DOCUMENTS

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